IN-04
77044
P-7

The Center/TRACON Automation System (CTAS): A Video Presentation

Steven M. Green and Jeannine Freeman

January 1992

NASA Technical Memorandum 103887

The Center/TRACON Automation System (CTAS): A Video Presentation

Steven M. Green, Ames Research Center, Moffett Field, California
Jeannine Freeman, SYRE, P.O. Box 81, Moffett Field, California

January 1992

NASA

National Aeronautics and
Space Administration

Ames Research Center
Moffett Field, California 94035-1000

Summary

Ames Research Center, working with the Federal Aviation Administration, has developed a highly effective set of automation tools for aiding the air traffic controller in traffic management within the terminal area. To effectively demonstrate these tools, the video AAV-1372, entitled "Center/TRACON Automation System," has been produced. This Technical Memorandum contains the script to the video and provides instructions for its acquisition.

Introduction

Ames Research Center, working with the Federal Aviation Administration (FAA), has been involved in the development of computer automation tools to aid air traffic controllers in traffic management within the extended terminal area. The product of this work is a set of tools referred to as the Center/TRACON Automation System (CTAS). The CTAS has undergone several years of laboratory investigation, and recently the FAA selected test and evaluation sites at Denver and Dallas-Ft. Worth as a first step in validating the technology.

The CTAS has three major components: the Traffic Management Advisor (TMA), the Center Descent Advisor (DA), and the TRACON Final Approach Spacing Tool (FAST). The major CTAS components are described in detail in references 1, 2, and 6. Results of several real-time simulation evaluations, involving Center and TRACON controllers as well as airline pilots, are presented in references 2–5. However, because of the system's advanced graphical interface and dynamic nature, an operational overview of CTAS features is best presented in video form.

The video AAV-1330 illustrates the CTAS. This video was filmed during a live traffic simulation. It follows several aircraft from en route cruise to the landing threshold to demonstrate how each major component of the CTAS assists the controller in a variety of traffic situations. The video is narrated, and is about 18 minutes long.

The video script follows. A copy of the video may be obtained through the Imaging Technology Branch (EDP), M/S 203-6, Ames Research Center, Moffett Field, CA 94035-1000.

Video Narrative

Air traffic controllers are responsible for safely routing air traffic. As traffic increases, the controller's job becomes more and more complex. Despite all of the advanced technology that is available for the pilot, there is little or no automation assistance available for today's controller.

However, researchers at NASA's Ames Research Center are working with the FAA to design automation tools to assist air traffic controllers. The Air Traffic Control automation team, part of the aircraft guidance and navigation branch, has developed CTAS, the Center TRACON Automation System. This system will help controllers increase capacity, reduce delays, save fuel, and reduce workload, all the while maintaining safety.

CTAS is designed to be flexible, dependable, and complementary to the way controllers handle traffic. Best of all, CTAS is adaptable to the individual preferences and techniques of each controller.

The system is illustrated here for the Denver arrival airspace. CTAS is made up of three major components:

1.   The Traffic Management Advisor, or TMA, determines the optimum sequence and schedule for all aircraft based on real time feedback from each Center and TRACON sector.

2.   The Center Descent Advisor, or DA, assists each Center controller in efficiently meeting the TMA's sequence while maintaining separation.

3.   The Final Approach Spacing Tool, or FAST, assists each TRACON controller in fine-tuning the arrivals for final approach.

The full capability of this system would take hours to demonstrate; this video will illustrate only the basic features of each component. What you are about to watch is a recording from a live simulation with qualified controllers and pilots.

First, let's watch the TMA in action.

The TMA's main display is its timelines. A timeline graphically orders the aircraft arrival times from the present, at the bottom, into the future, toward the top. For example, the current time is 15:19 Greenwich mean time, and this timeline shows United Flight 704 arriving at 15:41. The tags on the right side of the timeline represent eastern arrivals, and the tags on the left represent western arrivals.

There are three distinct timelines. The timeline on the right shows planned arrivals for traffic not yet under Denver radar coverage. This tells the traffic manager what to expect in the near future. The middle timeline displays estimated times of arrival, or ETAs, for aircraft under radar coverage. The ETAs are continuously updated by CTAS to accurately reflect each sector controller's

actions, as well as the effects of weather and aircraft type.

When aircraft enter the yellow regions, they are automatically scheduled by the TMA according to rules set by the traffic manager. The timeline on the left displays these scheduled times of arrival, or STAs. Notice that Continental 103 is nearly tied with United 504. The TMA scheduled both aircraft to allow for in-trail separation. There are two regions for automatic scheduling: the region at the top schedules traffic in the Center; the region at the bottom schedules traffic in the TRACON and allows for changes in the arrival flow such as pop-ups and missed approaches.

At any time, the traffic manager/controller can manually change the scheduling process. Here the controller is using a computer mouse to reserve a slot for a heavy aircraft. The controller can also block a section of the schedule for various situations such as snow removal or departures. In addition, the controller can set the sequence, change the acceptance rate, or modify any one of a hundred different rules with just a click of the mouse.

As the center schedules are set by the traffic manager, the TMA distributes the schedule information to each sector. The center controllers then use the DA to meet the schedule.

This is a plan-view display of the entire Denver center airspace. The main arrival flow converges on Denver from four directions. We will focus on the northeast arrival gate to illustrate the DA in action.

The most notable features of this plan-view display are the timeline and the advanced graphical interface. Here the controller will use pop-up menus instead of function keys to allow the viewer to follow his interaction with the DA.

Like the TMA, this timeline displays aircraft IDs in order of arrival, with the earliest arrival at the bottom. The blue tags in the left column are scheduled metering-fix arrival times. The metering fix for this sector is shown in blue. The scheduled times are continuously updated by the TMA for all aircraft in this sector. The green tags in the left column are the ETAs. These ETAs are continuously updated by the automation to reflect the actions of both the controller and pilot. The trajectory analysis used to compute these ETAs takes into account aircraft performance, pilot procedures, and atmospheric conditions.

The controller's objective is to match the ETAs to the scheduled times. This will ensure a smooth merging of traffic in the adjoining sectors. Here we see the controller displaying the schedules for all Denver arrivals.

The orange tags show how the arrivals from other sectors will mesh with this sector's traffic.

Let's watch how the controller uses the DA to meet the scheduled arrival times. For example, the timeline shows USAir 421 scheduled to cross the metering fix at 48 minutes, 21 seconds after the hour. The aircraft's current ETA is 46:30, nearly two minutes ahead of schedule. To receive advisory information, the controller selects the aircraft. The yellow bar indicates the range of arrival times possible with speed control only. This gives the controller an instant picture of how much speed, vectoring, or holding is needed. Notice that the aircraft's timeline ETA tag, highlighted in yellow, now matches the aircraft's schedule tag, in blue. This means that the DA has determined a descent profile, with speed, that will meet the time. The DA is displayed on the fourth line of the aircraft's data tag. Here we see the DA advising a top of descent at 77 nautical miles DME to Denver with a descent speed of 240 knots indicated. In addition, the DA has displayed the location of the top of descent in magenta. When the controller is satisfied with the advisory, the clearance is issued. The automation then tracks the aircraft and reports any deviation from the plan.

At any time, the controller may ask the automation to combine cruise, descent, and vectoring advisories with just a click of a button. In addition, the controller may ignore the advisories, and the DA will continually compute new ones in response to the controller's actions.

Next, we'll illustrate some of the vectoring features.

Although most arrivals follow standard routes, the DA can analyze any path desired by the controller. For example, American 605 is currently on a magnetic heading of 260 degrees and is not on an established route. The controller has set the DA to intercept the next jet route. Here we see the DA projecting American 605 to intercept J157 and proceed along that route to Denver. As the aircraft's course varies, the automation reanalyzes the trajectory and updates the display and ETA. To bring the aircraft directly to Smity intersection instead, the controller just selects the waypoint capture mode. Now the display shows a turn arc to the capture point, as well as the magnetic heading to turn to. Notice that as the aircraft moves, the turn arc and the ETA are updated to reflect any changes in the aircraft's position and speed as well as wind changes. As the controller modifies the routing, the DA automatically recomputes a new speed profile to meet the schedule.

The DA also provides a mode to assist in vectoring for sequencing. Here we see that United 321 cannot achieve its scheduled time, even at its slowest speed. The timeline shows that at least three minutes of delay must be

absorbed by vectoring. To solve this problem, the controller just selects the auto-pathstretching mode. Now the DA advises when to turn the aircraft back on route to meet the scheduled time. The controller may even change the capture point "on the fly" and the DA will update the advisory.

In addition to providing advisories to meet the TMA's schedule, the DA also assists the controller in resolving potential conflicts. It is important to understand that, although the TMA's schedule is conflict free at the metering fix, the complex nature of descent trajectories may result in minimum separation at a point ahead of the metering fix. With this in mind, the DA was designed to predict conflicts up to 20 or 30 minutes ahead of time.

For example, USAir 342 (a Boeing 737), and United 894 (a DC-10), are currently separated by 8 nautical miles and 4,000 feet. Both are arriving in Denver, and their scheduled arrival times are conflict free at the metering fix. However, if the controller maintains their present routing and speed, the DA is predicting a future separation violation. The conflict-prediction feature indicates which aircraft are involved, when the conflict will happen (after eight minutes, in this case), and where the conflict will first occur. With this early warning, the controller can easily resolve the potential conflict with small changes. Once the potential conflict is resolved, the DA removes the indicators from the display.

In general, the DA is a flexible tool for the center controller. It allows maximum creativity while providing reliable information for the safe and efficient sequencing of arrival traffic.

As the traffic flows into the TRACON, the TMA updates the schedule and sends the information to each TRACON sector. The TRACON controller then uses FAST (the final-approach spacing tool) to fine tune the arrival flow.

Here we will focus on the TRACON and watch how the northeast and northwest arrival flows are merged for landing on Denver Stapleton's runway 26 Right.

In general, the TRACON has less time and airspace to work with than the Center does. In this light, FAST was designed to anticipate the TRACON controller and provide advisory information as it is needed, with little or no controller interaction required.

FAST monitors each TRACON arrival and continually updates its ETA to reflect changes in path and speed. The ETA and schedule for each arrival is then displayed on the timeline, much like the Center's DA. The ETAs are shown in the right column, in green. The schedules are

shown on the left; blue schedule tags are for arrivals from the west, white tags for arrivals from the east.

If an aircraft's ETA differs from its schedule, FAST automatically provides speed and heading advisories to compensate. The controller may use the advisories or ignore them; in any case, FAST will sense the action and adapt to the controller's plan. The best way to gain an understanding of FAST is to watch it in action.

We'll follow American 304 as it approaches from the northwest and is set up for an ILS approach to runway 26 Right. The controller is now illustrating the most efficient path under nominal conditions. As American 304 approaches its "downwind" leg, FAST displays its first advisory: a slowdown to 210 knots indicated airspeed. The orange marker indicates the recommended position to issue the clearance.

Now that American has completed its speed adjustment and has been turned downwind, we see that the updated ETA is 25 seconds behind schedule. FAST senses this difference and is now computing a new trajectory to meet the goal. When the time is right, FAST displays its next advisory. Keep in mind, though, that controllers are free to handle the traffic as they wish. Here, FAST is recommending a turn to base; the marker indicates when to issue the heading, the arc indicates the planned path, and the number is the magnetic heading that accounts for wind. Depending on the pilot's response, FAST resynthesizes a new solution to meet the time. Here, FAST is recommending another speed change, this time to 170 knots indicated airspeed. The final turn to intercept will bring the aircraft's arrival time to within a few seconds of the schedule.

Interactive features, such as those demonstrated for the DA, are also available if the TRACON controller desires to use them.

Next, we'll observe the handling of a missed approach which will demonstrate the unique flexibility of the overall system. The missed approach will be handled in three major steps. The first step is sequencing, the second is rescheduling, and the third step is controlling to meet the schedule. Watch as United 357 executes a missed approach.

The controller is now defining the reentry path. FAST analyzes the trajectory and computes an ETA. Using the plan-view display and timeline, the controller can visualize the resulting sequence. When the controller is satisfied with the sequence, a rescheduling action with the traffic manager is initiated. The traffic manager, with the help of the TMA, modifies the overall arrival flow to accommodate the TRACON. The rescheduling is confirmed electronically in seconds, and now the TRACON

3

controller handles the missed-approach aircraft as though it were just another arrival.

CTAS was designed with one idea in mind: to provide the controller with useful and timely information. CTAS allows the controller more freedom to manage traffic while the computer performs the complex calculations.

Each component of CTAS assists the controller with vital functions: traffic management, sequencing and separation, and final-approach spacing. However, together these three tools provide controllers with an unprecedented situational awareness.

References

1. Erzberger, H.; and Nedell, W.: Design of Automation Tools for Management of Arrival Traffic. NASA TM-102201, 1989.

2. Green, S. M.; Davis, T.; and Erzberger, H.: A Piloted Simulator Evaluation of a Ground-Based 4D Descent Advisor Algorithm. AIAA Paper 87-2522, August 1987.

3. Davis, T. J.; and Green, S. M.: Piloted Simulation of a Ground-Based Time-Control Concept for Air Traffic Control. NASA TM-101086, 1989.

4. Tobias, L.; Volckers, U.; and Erzberger, H.: Controller Evaluations of the Descent Advisor Automation Aid. NASA TM-102197, 1989.

5. Williams, D. H.; and Green, S. M.: Airborne Four-Dimensional Flight Management in a Time-Based Air Traffic Control Environment. NASA TM-4249, 1991.

6. Davis, T. J.; Erzberger H.; and Bergeron, H.: Design of a Final Approach Spacing Tool for TRACON Air Traffic Control. NASA TM-102229, 1989.

7. Davis, T. J.; and Erzberger H.: Simulator Evaluation of the Final Approach Spacing Tool for TRACON Air Traffic Control. NASA TM-102807, 1990.

REPORT DOCUMENTATION PAGE

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	January 1992	Technical Memorandum

4. TITLE AND SUBTITLE

The Center/TRACON Automation System (CTAS): A Video Presentation

5. FUNDING NUMBERS

505-64-13

6. AUTHOR(S)

Steven M. Green and Jeannine Freeman (SYRE, Moffett Field, CA)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Ames Research Center
Moffett Field, CA 94035-1000

8. PERFORMING ORGANIZATION REPORT NUMBER

A-91223

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

National Aeronautics and Space Administration
Washington, DC 20546-0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

NASA TM-103887

11. SUPPLEMENTARY NOTES

Point of Contact: Steven M. Green, Ames Research Center, MS 210-9, Moffett Field, CA 94035-1000
(415) 604-5431 or FTS 464-5431

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Unclassified-Unlimited
Subject Category – 04

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Ames Research Center, working with the Federal Aviation Administration, has developed a highly effective set of automation tools for aiding the air traffic controller in traffic management within the terminal area. To effectively demonstrate these tools, the video AAV-1372, entitled "Center/TRACON Automation System," has been produced. This Technical Memorandum contains the script to the video and provides instructions for its acquisition.

14. SUBJECT TERMS

Air traffic control, Air traffic control automation, Automation, Simulation, Traffic management

15. NUMBER OF PAGES

6

16. PRICE CODE

A02

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified		